EFFECTIVE STRATEGIES FOR MANAGEMENT OF DEPARTMENT OF THE ARMY RESEARCH AND DEVELOPMENT IN ADVANCED CERAMIC MATERIALS

by

JAMES RUSSELL HANN, 1951-

A THESIS

Presented to the Faculty of the Graduate School of the

UNIVERSITY OF MISSOURI-ROLLA

In Partial Fulfillment of the Requirements for the Degree

MASTER OF SCIENCE IN CERAMIC ENGINEERING

1990

Approved by

Robert E. Moore, Advisor

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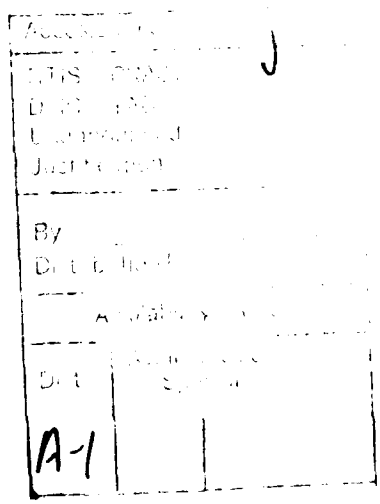
ABSTRACT

The strategies employed to manage research and development programs are not always tailored to the organizational culture of the researching institute. This paper investigates some of the key issues involved in managing the diverse program of research conducted by the Department of the Army in advanced ceramic materials.

This study focuses on the attitudes and opinions of active researchers in three different organizational environments and attempts to correlate the differences between these groups. A mail questionnaire is used to solicit data from the groups. The goal is to test the effectiveness of current strategies, as the respondents perceive them, within and between the three groups.

Significant results are obtained regarding researcher productivity, research equipment needs, and funding support. Important analogies are drawn regarding researcher productivity and efficiency of research efforts.



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My sincere appreciation is extended to Dr. Robert Moore for his support, guidance and understanding during this research. Thanks also to Dr. Kluczny, Dr. Day, and Dr. Ownby for their efforts both on my committee and in the classroom.

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A special thanks to my wife, Allyson, who motivated me to complete this work, and supplied the hours needed to do it, through her caring attention to both me and our three children.

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LIST OF ABBREVIATIONS

AF	Air Force
comm	commercial
DA	Department of the Army
DARPA	Defense Advanced Research Projects Agency
DOD	Department of Defense
DOE	Department of Energy
DK	don't know (survey response)
Duncan	Duncan's Multiple Range Test
FY	fiscal year
govt	government
N	population of interest
NASA	National Aeronautics and Space Agency
NBS	National Bureau of Standards
NSF	National Science Foundation
p	probability level (statistical)
R & D	Research and Development
RD & A	Research, Development and Acquistion
RDT & E	Research, Development, Testing and Evaluation
Tukey	Tukey's Studentized Range Test
univ	university
USA	United States Army
USN	United States Navy

I. INTRODUCTION

A. BACKGROUND

1. Author's Intent. Strategy is a term used in military and civilian enterprises to mean grand plans made to counter what an adversary might or might not do. Most dictionaries still define strategy as both a science and an art, avoiding any controversy. Oddly the root of strategy, strategem, is a maneuver designed to deceive or surprise or more commonly, a deception.

Three of the more commonly used definitions of strategy will typify the intent of this investigation.

> (1) general programs of action and deployment of resources to attain comprehensive objectives; (2) the program of objectives of an organization and their changes, resources used to attain these objectives, and policies governing the acquisition, use, and disposition of these resources; and (3) the determination of the basic long-term objectives of an enterprise and the adoption of courses of action and allocation of resources necessary to achieve these goals. (Koontz 1988, 63)

One of the author's requirements under the United States Army (USA) Advanced Civil Schooling program is to research a topic which will support an Army program or problem. The author's next position, following graduation, will be Research and Development (R & D) Coordinator at the Cold Regions Research & Engineering Laboratory and will require both technical and management skills. Accordingly, a review was made of plans and program management in R & D,

followed by a wide range of issues; including procurement, acquisition, program budgeting, and U.S. Government, Department of Defense (DOD), and Department of the Army (DA) regulations and procedures. To maintain a concentration in ceramic engineering, the investigation was then limited to the strategies used in DOD and DA research and development activities in advanced ceramic materials.

2. Problem Statement. The widely diversified nature of the DA research activities often make it difficult for even those working in the system to relate their efforts to the goals of the Army and the strategies used to reach them. The problem, simply stated is: What is the relation between Department of the Army research objectives (the mission) and the strategies used to complete them?

B. ARMY RESEARCH OBJECTIVES

Most advanced material research for the Army is conducted by several of the 31 R & D organizations attached to the Army Material Command(AMC). The Materials Technology Laboratory (MTL) in Watertown is responsible for advanced material research, including basic research in advanced metals, composites, and ceramics (Office of Technology Assessment, 1988).

General William Tuttle, Jr., AMC Commander, has established the objectives of the command by focusing on seven major missions.

> 1. Equipping and sustaining a trained and ready Army (the first mission among equals);
>
> 2. Supplying equipment and services to other nations through the Security Assistance Program;
>
> 3. Developing and acquiring non-major systems and equipment;
>
> 4. Providing development and acquisition support to Program Executive Officers [and] Program Managers;
>
> 5. Defining, developing, and acquiring superior technologies;
>
> 6. Maintaining the mobilization capabilities necessary to support the Army; and
>
> 7. Improving productivity and quality of life.
>
> (Israel, 1990, 1-2)

Missions 3,4,5, and 6 form the core of research, development and acquisition (RD & A) for the command. The strategic plans of AMC include the Technology Base Master Plan and Technology Base Investment Strategy, which are designed to plan, program and budget for the technological requirements of tomorrow's soldier.

C. RESEARCH METHODOLOGY

Nearly all of the different forms of R & D organizations fall into one of the categories listed below:

* Government Laboratories
* Federal Contract Research Centers
* Not-for-Profit Institutions
* Independent Nonprofit Organizations
* Corporate R & D Laboratories
* Educational Institutions
* Private Profit-Making Institutions

(Francis, 1977, 3-7)

Ignoring the minor categories of laboratories (less than 10% of funded ceramic research), that left government labs, commercial labs and university facilities as the research variables selected for investigation.

It became obvious that it would be difficult to quantify the relation between Army research objectives and the resulting strategic plans. What would be possible is to quantify the relationship between a researcher's attitude about current strategies and their effect on his work, and ultimately the accomplishment of the objective.

With only one, homogeneous group working on an objective, a manager could adequately provide the support to complete the mission. In this investigation, it is theorized that the diversity of the backgrounds, ages, environments, salaries, etc., make it impossible to satisfy all the basic management requirements needed for productive effort.

The basic research hypothesis is then: There exists a significant difference in how researchers from these three basic categories interpret the effects of current federal strategies on their research efforts. An attitude survey was designed to collect needed data. Details of the survey format are in section III and a copy of the questionnaire and cover letter are at app. A. References for development of the problem and hypothesis include Kingery, 1986; Bass, 1967; Cetron, 1971; Brook, 1986; and Schuman & Presser, 1981.

II. REVIEW OF LITERATURE

A. BACKGROUND

There is a large volume of material available on the technical aspects of U.S. Army research in ceramics and separately, the management of research programs, but little to tie the two together. Since one of the author's goals was to learn as much as possible about the wide variety of factors effecting U.S. Army RDT & E, the literature review began broadly. My guide, although not very scientific, is based on many years of military tradition. A leader (manager) should be capable of assuming the duties of the next higher position at any time and be familiar with the procedures two levels higher. With this rule in mind, I reviewed existing literature in the field.

B. FUNDING

1. Congressional Appropriations. Most articles and books all address the problem of funding in one form or another. The DA, and ultimately the university and commercial laboratories with DA contracts, must rely on Congress to appropriate adequate funds for research. In 1990, virtually all Congressional leaders sought to maximize the "peace dividend" from the reduced threat of Soviet bloc powers. While valid in theory, there remained many problems in reaching that goal. The current Fiscal Year (FY) 1991 budget reflects an

overall DOD and DA decrease, while maintaining somewhat adequate levels of research spending as shown in Table I.

Table I. Department of Defense Research Development Test and Evaluation Fiscal 1991 Revised Budget*

R & D Category	FY 1989	FY 1990	FY 1991
Research	951	924	978
Exploratory Development	2,541	2,403	2,458
Advanced Development	10,376	10,340	11,107
Engineering Development	11,413	11,302	10,942
Management & Support	2,808	2,530	2,849
Operational Systems Dev.	9,417	9,219	9,760
Total RDT & E	37,506	36,718	38,093

* Dollars in Millions (Gilmartin, 1990, 59)

Funds available for government research projects reflect current Presidential and Congressional priorities. Therefore, funding varies over time for different projects. Based on obligations for 1976 and budget authority for 1986 the national defense share of federal R & D funding rose from 50% to 73% at the expense of all other categories of endeavor but general science (NSF, 1986, 2).

The Army subdivides its budget into seven major appropriations categories. Table II summarizes the shifts happening within the budget categories. Top Defense Department officials have reassured defense industries that they will preserve the National R & D base (Fulghum, 1990, 29; Gilmartin, 1990, 59; Bond, 1990, 63) while just a few months ago the effect of mandatory budget cuts on R & D were less optimistic (Henderson, 1989, 35).

Table II. United States Army Budget Summary by Appropriations Category*

Appropriations Category	FY1990	FY1991
Military Personnel	29,800	30,000
Operations and Maintenance	25,600	26,500
Procurement	14,300	10,600
RDT & E	5,400	6,000
Military Construction	1,100	900
Family Housing	1,500	1,500
Stock Fund	0	600
Total Funding	77,700	76,100

* Dollars in millions (Adelsberger, 1990)

Army RDT & E managed an 11% increase at the expense of all other categories in terms of real dollars. This reinforces the strategy of maintaining a "ready reserve" structure instead of a standing, equipment-heavy force. The emphasis here is to have the technology base necessary to support any operations around the world.

2. Engineering Ceramics Funding. The United States government is pursuing several major programs in high-temperature engineering ceramics. Engineering ceramics are defined as oxides, nitrides, borides and silicides reinforced with either particles, whiskers, or continuous filaments. It is difficult, if not impossible, to narrow the focus of funding support to accurately gauge funding directed to this research. The data in Table III shows a best estimate of funding through DOD sponsored activities.

To put defense related costs in perspective, it is useful to look at totals for Federal research and development. The FY 1989 total of $62.5 billion contained an estimated $1.3 to $1.5 billion for materials research. This amounts to only 2% of the Federal total. This $1.3 billion is then divided between the defense agencies and numerous nondefense agencies, such as the Department of Energy (DOE), National Aeronautics and Space Agency (NASA), National Science Foundation (NSF), National Bureau of Standards

(NBS), and the Bureau of Mines. The funding for R & D is heavily fragmented and difficult to track exactly where each dollar is going.

Table III. DOD Science and Technology Investment in Engineering Ceramics in Programs 6.1, 6.2 and 6.3A. (Army + Navy + Air Force + Defense Advanced Research Projects Agency (DARPA) Totals).*

Fiscal Year	Material		
	Ceramic-Matrix Composite	Metal-Matrix Composite	Carbon[2] Composite
1979	1.4	12.9	6.1
1980	1.7	13.9	11.1
1981	2.0	19.7	13.3
1982	2.0	19.2	9.8
1983	5.9	19.8	10.5
1984	9.3	23.1	10.7
1985	9.5	24.3	10.8
1986	11.2	21.6	18.8
1987	21.6	29.7	13.2
1988	26.8	24.0	12.7
1989	27.8	24.6	14.0

* Dollars in Millions (Maxwell, 1988, 135-7)

C. CRITICAL TECHNOLOGIES

Public Law 100-456, the National Defense Authorization Act for FY 1989 was enacted to provide Congress annually with a Critical Technologies Plan for the Department of Defense. Clearly U.S. Defense

strategies weighed heavily when officials defined the selection criteria for these technologies (Bond, 1990).

While Defense officials were compelled to provide Congress with this new report beginning in FY 1990, it was equally clear that they did not intend to abandon the DOD Science and Technology Program which formed the basis for all the long-range strategic planning in these areas to date (DOD, 1989). There are several technologies included in both the FY 1990 and FY 1991 report which will involve either a direct or indirect effort by ceramic engineers. They are listed below:

* Composites - materials possessing high strength, low weight, and/or able to withstand high temperature for aerospace and other applications.

* Superconductivity - the fabrication and exploitation of superconducting materials.

* Semi-Conductor Material - the preparation of high purity GaAs and other compound semi-conductor substrates and thin films for microelectronic substrates.

* Air-Breathing Propulsion - light-weight, fuel efficient engines using atmospheric oxygen to support combustion.

Complementing, or maybe compounding, the DOD Critical Technologies Plan and Science and Technology

Plan is the U. S. Army's series of technological thrusts known as fields of technical endeavor (FOTEs). The ten FOTEs are meant to be tailored to the Army's specific role and are managed by the Army's Laboratory Command (LABCOM), Adelphi, Maryland (Rhea, 1990).

These multiple strategies may have the tendency to create so many sub-strategies and plans that it is difficult for managers to focus clearly and completely on policies which are truly critical to U.S. competitiveness and national defense. Within the last two years several DOD agencies have adopted the management philosophy of total quality management in an effort to improve the products and services of the Department (Strickland, 1989).

D. STRATEGIES FOR THE 1990s

1. Successful Programs. One of the most practical methods for improving management strategy is to copy someone who has been successful. Analysis of a number of successful commercial programs such as the IBM 360 computer, the Boeing 767 transport, and the Hughes communication satellite, provides features typified in the most successful commercial programs (President's Blue Ribbon Commission, 1986).

a. Clear command channels. A commercial program manager has responsibility for his program, and a short, unambiguous chain of command to his chief executive officer (CEO),

group general manager, or some comparable decision-maker.

b. Stability. At the outset of a commercial program, a program manager enters into a fundamental agreement or "contract" with his CEO [Chief Executive Officer] on specifics of performance, schedule, and cost.

c. Limited reporting requirements. A commercial program manager reports only to his CEO. Typically, he does so on a "management-by-exception" basis, focusing on deviations from the plan.

d. Small, high-quality staffs. Generally, commercial program management staffs are much smaller than in typical defense programs, but personnel are hand-selected by the program manager and are of very high quality. Program staff spend their time managing the program, not selling it or defending it.

e. Communications with users. A commercial program manager establishes a dialogue with the customer, or user, at the conception of the program when the initial trade-offs are made, and maintains that communication throughout the program.

f. Prototyping and testing. In commercial programs, a system (or critical subsystem) involving unproven technology is realized in prototype hardware and tested under simulated operational conditions before the final design approval or authorization for production.

The Department of Defense implemented many of the management recommendations of what was known as the Packard Commission between 1986 and 1988. President Bush also ordered a Defense Management Review in 1989 to eliminate wasteful and duplicative regulations and directives (Scott, 1990).

2. Educational System. The backbone of any research program is the quality of the people in it.

Many senior Defense Department officials cite the decline of our educational system as a major cause of our declining industrial and economic competitiveness (Atwood, 1990). Senators Ted Kennedy and Mark Hatfield introduced legislation aimed at making American students first in the world in mathematics, science, and engineering during the next decade (Acker, 1990).

Any weaknesses in the educational system will propagate throughout the laboratories until both the quantity and quality of American research becomes unacceptable. A cooperative effort between government, industry and universities has been tried with limited success. Improving both the educational and commercial exchange between these three partners in advanced material development is discussed by Adam, Norman, Joseph Lee and the National Research Council.

3. Strategic Concerns. Both Robert O'Connell and Martin van Creveld elaborate on one of the oldest, but often overlooked, problems of war - raw materials. They cite several examples of critical shortages of needed materials which can be equated to the need for extremely high-grade powders for many of the semiconductor, superconductor and ceramic composite applications.

People are rarely thought of in strategic terms, yet in research and development they are probably the most critical asset in the system. Without a thorough

understanding of human relations, a manager will never really tap into the full potential of his personnel. A R & D organization must successfully incorporate the social, administrative and technical systems within a framework of efficiency, productivity and professionalism (Hodgetts, 1990).

The civil service and contract employees of DA and DOD must be provided the same opportunities for retention, promotion and professional development as their counterparts in industry and foreign employment (Fox, 1988).

The Office of Technology Assessment in 1988 reported to Congress on a variety of issues to include: top management erosion, funding during times of tight budgets, the quality and utility of government labs, dependence on foreign sources for technology and unnecessarily regulated specifications.

Management of this potpourri of variables is difficult, but not impossible. The key is to establish which issues are shared by the empolyees of your organization, and then plan and implement policies to improve those areas. Identification of these key issues is one of the goals of this investigation.

III. RESULTS AND DISCUSSION

A. EXPERIMENTAL METHOD

1. Questionnaire Development. Although the personal interview far overshadows other types of survey methods, both time and financial constraints prohibited its use for this research. The two most serious drawbacks of the mail questionnaire are possible lack of response and inability to check the responses given. Response rates of less than 40% or 50% are common, with best returns in the range of 50% to 60% (Kerlinger, 1986, 380).

The author attempted to improve those percentages by purposely simplifying the format of the questionnaire and limiting the length to one page, front and rear. Naturally this also limited the scope and the clarity of some of the questions, which made analysis difficult. There were 204 questionnaires mailed with 16 returned unopened for incorrect or insufficient addresses. Of the remaining 188 a total of 90 were returned within an adequate time for analysis. The response rate then equalled 48 percent.

Appendix A shows the cover letter and questionnaire mailed to respondents. A more detailed analysis of question format and responses obtained is at section III.B. of this paper. The main reference used for question development was Schuman and Presser's Questions and Answers in Attitude Surveys. A

significant effort was made to ensure that both open and closed questions appeared, middle alternatives were provided when applicable and questions were as balanced as possible in wording and tone. The author purposely omitted the don't know (DK) response in several cases because it was reasoned the middle alternative served as an adequate response for that condition.

2. Respondent Selection. Survey respondents were selected at random from a variety of sources. The three basic categories being compared were commercial, government and university researchers, as discussed in Section I.C. The target group for all categories was active scientists and researchers, as opposed to managers, executives and government leaders whose views were widely published already. An attempt was made to evenly access all three groups by increasing the mailing for commercial and university groups. The author expected a better return rate from government facilities because of his military association and past experience with federal employees. The total number of questionnaires mailed and return rates for each category are as follows:

Commercial - 72 mailings - 34.7% return rate (25)

Government - 61 mailings - 59.0% return rate (36)

University - 71 mailings - 40.8% return rate (29)

Individuals were selected from one of the following sources with the only criteria being their work had to be related to ceramic materials in some way:

Journal of the American Ceramic Society
American Ceramic Society Bulletin
Army Research Development and Acquisition Magazine
Materials Engineering Magazine
Materials Science and Technology Magazine
Advanced Materials and Processing Magazine

Normally an individual was selected who had recently published an article in the advanced ceramic field. The logic being that the individual would have to be an active researcher or manager of research in order to author an article.

3. Response Coding. The coding of responses was dependent on the type of analysis which was envisioned for the question. For questions 1, 2, 5, 7, 8 and 10 a simple comparative analysis by frequency or percentage was adequate to obtain the desired data. A more detailed treatment of means, variance, frequency and correlation effects was necessary for the remainder of the questions.

Questions 6 and 9 were anticipated to provide the most valid results because they captured not only the response, but the strength of the attitude of the respondent. The original plan called for coding the responses 1 through 5 to capture the general trend of responses and allow more formal treatment using computerized statistical programs. A sixth response

level of 0 had to be added to account for a small number of respondents who failed to answer one or more questions and thus generated a no response level.

B. RESULTS AND ANALYSIS

1. General - Question 1. This section presents the results and analysis of the survey questions in numerical order as on the questionnaire. The purpose of question 1 was to establish some historical background on the respondent and confirm his major category placement. Appendix B, Job Title Listing, is a list of the job titles reported, in alphabetical order and without repetition. Figure 1 depicts the employment length distribution of respondents.

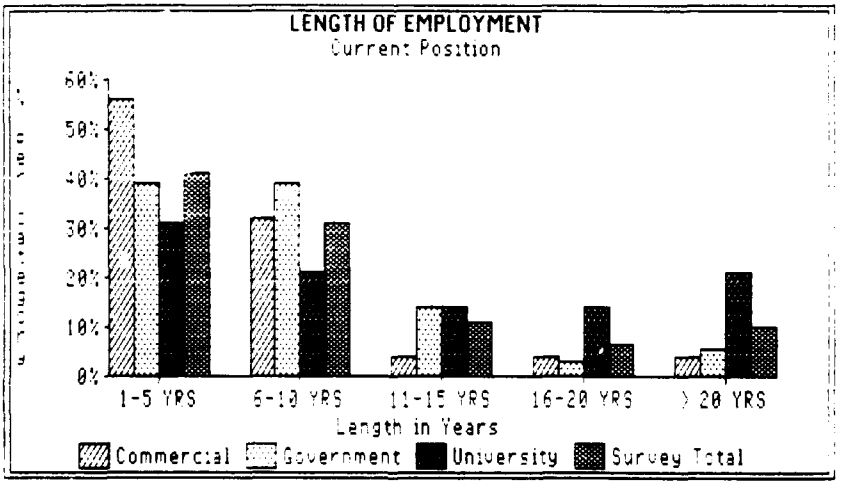

Figure 1. Length of Employment Distribution by Category for Current Position.

The relatively flat distribution of university respondents is most likely due to the majority reporting as professors without distinguishing the appropriate level attained. The age group distribution (fig. 2) represents typical ages expected from each category and is fairly uniform.

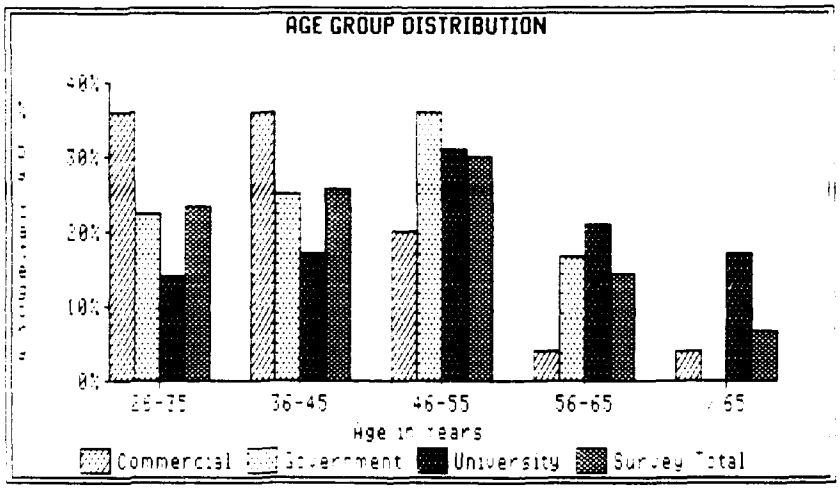

Figure 2. Age Group Distribution by Category.

2. Question 2. The purpose of question 2 was to establish the degree which the respondent is involved in ceramic related research. The goal was to survey individuals that use 50% or more of their effort on ceramic technology. Figure 3 shows that 71 % of the total respondents devote more than 50% of their effort in ceramics.

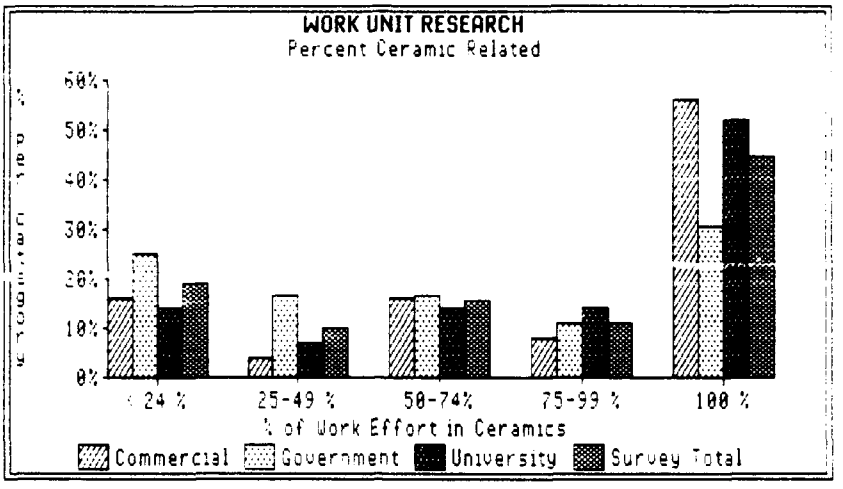

Figure 3. Work Unit Research Effort in Ceramics.

3. Questions 3 & 4. The purpose of these questions was to correlate the size of the work unit to the number of personnel supervised for each category. It was theorized that there was a considerable difference in the spans of control between the categories. The results were inconclusive for several reasons,app. C, figs. 15 & 16.

First, there was obviously some confusion over the wording of the question when several respondents supervised more people than they had in their work unit.

Second, the size distribution brackets were selected based on reasonable estimates of organizational spans from other studies such as British consultant Lyndall Urwick. The question should have

been left open-ended to allow exact answers and a more realistic distribution.

4. Question 5. The purpose of this series of questions was to establish the degree of experience which the survey group has with DA, DOD and other federal agencies. If a majority of the respondents did not have this type of experience, their interpretation of federal policies in questions 6 and 9 would be suspect. Figure 4 represents the number of individuals responding either yes or no to questions 5 and 5a, with DK responses negligible.

Only 19% of the total surveyed had no experience with either defense or nondefense related funding. Of particular note, all of the university researchers responding to the survey claimed some experience with federally funded projects.

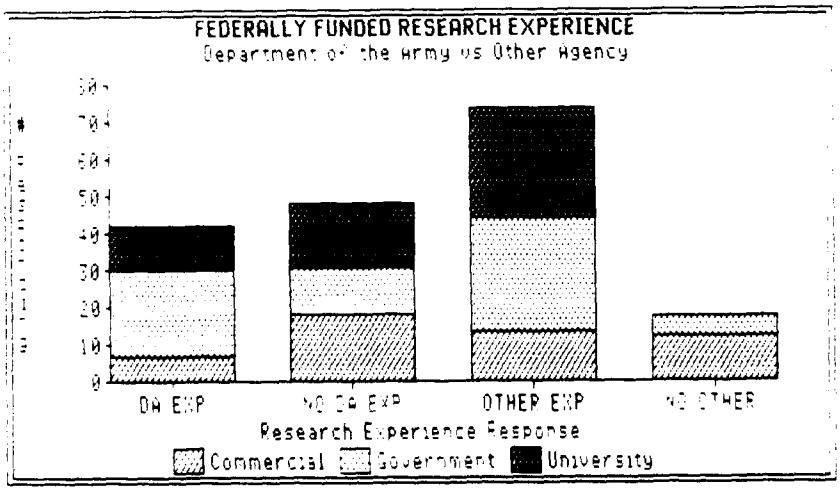

Figure 4. Experience Conducting Federally Funded Research.

Figures 17 and 18 are included in Appendix C. The Department of Energy and National Science Foundation were clearly the largest supporters of research for all three categories, without considering DOD and DA levels. Figure 18 depicts the relative importance of federal funding to the different categories. Clearly our universities continue to depend heavily on federal funding for their research.

Figures 18a, 18b and 18c at Appendix C, highlight what the author believes is the most significant sectors of each category in funded research. Commercial activities show an extremely low percentage of government funding activity. This corresponds with previous research conducted which established a general mistrust of the government by the commercial sector and may also partially explain why this category registered the lowest return rate for this survey.

The 25% of government researchers responding that are funded, in part, by other than government sources is an interesting departure from the past (fig. 18b). There is an increasing amount of contract work conducted for both manufacturers and state and local agencies. In many cases the scientific expertise in a particular field of study is located at a government facility, and that expertise is made available to the public through contractual arrangements.

University totals in fig. 18c depict the degree that educational facilities depend on government

sources for research funding. Any significant cutbacks in DOD, DOE or NSF funding would immediately impact over 80% of the university researchers surveyed.

5. Questions 6. The results from this question, along with question 9 and 10, were not conclusive in establishing striking differences between the three groups tested. The author used a variety of statistical procedures (SAS, 1985) , but was limited by the small sample size per category. This eliminated most common frequency testing procedures like the chi-squared test.

Consequently, the analysis of these questions will focus on two main areas, 1) the ANOVA treatment of each variable, and 2) the evaluation of substantial concurrence or nonconcurrence within and between groups. Note that the second treatment of the data may depart somewhat from the research hypothesis, but the analysis has great value for a manager when he is establishing his priority of effort.

Questions 6 and 9 are evaluated as follows: all graphical data which is not statistically significant, from the variance analysis, can be found in Appendix C. The figures for questions 6a-6h and 9a-9i do not depict the no response value, although the total used to calculate percentage still reflects the total responses. Therefore, the total of the bar graphs may or may not add up to 100%. The tabular data resulting from this survey is at appendix D. Data was coded at a

value of 1 for "strongly agree" to a value of 5 for "strongly disagree". The number of respondents (N) for each category is 25 for commercial, 36 for government and 29 for university, for a survey total of 90.

a. Question 6a - Quality of Research. There were no significant differences in the group responses. The term "quality" denoted too many qualitative interpretations to sharply define the categories or even the general response, fig. 20, app. C.

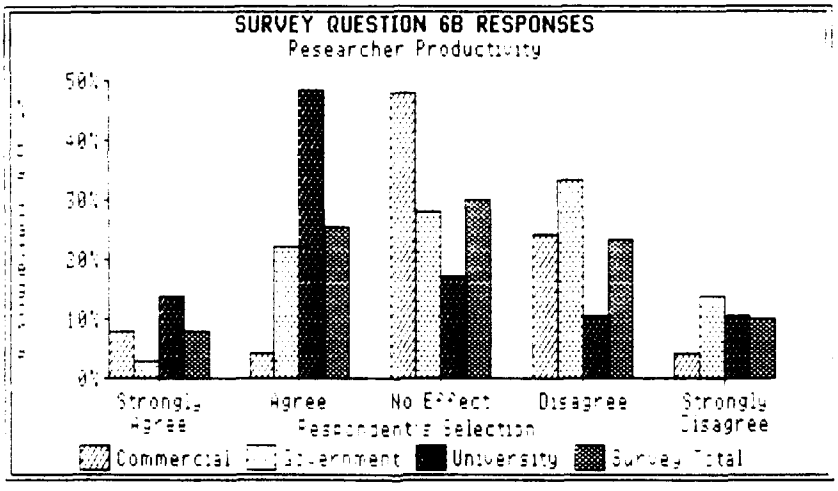

Figure 5. Survey Question 6B - Researcher Productivity.

b. Question 6b - Researcher Productivity. The variance value of model $F = 3.77$ at $p < 0.05$ level for this question, fig. 5. Also significant were Duncan's Multiple Range Test (Duncan) and Tukey's Studentized Range Test (Tukey). The significant difference is that the government (govt) group more strongly disagreed

with the statement than the university (univ) group. Neither the govt or univ group varied from the commercial (comm) group significantly.

c. Question 6C - Research Efficiency. The variance results were not significant, however, there is a difference between the govt and comm groups using the Duncan and Tukey tests. This question had the highest (disagreeable) mean score for the total sample, and the comm and govt categories, fig.21, app. C.

d. Question 6D - Employee Retention. Again the variance result does not meet the 0.05 significance for the F value, but there is a difference in the Duncan and Tukey values. In this case the comm and univ values are significantly different. This difference can be attributed to the univ group ranking this parameter highest in mean value for all their question 6 responses, while the other two groups did not feel strongly about this issue, fig. 22, app. C.

e. Question 6E - Equipment Procurement. The differences in variance for this question are significant at the 0.05 level with F = 3.44, fig 6. This is attributable to the univ group assigning it their lowest (agreeable) mean value for this set of parameters while the comm and govt each ranked it a much higher mean value, Table V, app. D.

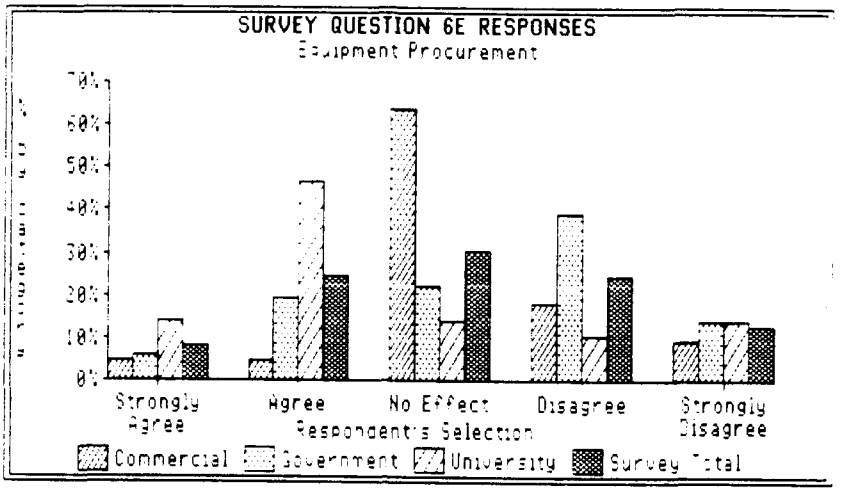

Figure 6. Survey Question 6E - Equipment Procurement.

One could deduce from this dichotomy that university researchers are procuring new equipment using government funding while commercial and government researchers are not. In reality, government researchers in certain segments may be experiencing budget cutbacks due to the deficit reduction efforts of the Administration.

f. Question 6F - Raw Material Availability. The raw material issue is quite obviously one of concern only to global strategic planners. All three groups did not feel that there is a problem with raw materials at this time, fig. 23, app. C.

g. Question 6G - Information Access/Availability

There was no significant difference between groups on this issue. In fact, it was attributed the lowest mean score for the total group, the commercial category and the government category, Table V, app D. While it is true that part of this effect is due to the large number of respondents that felt policies have no effect (value 3), there is enough evidence to imply this is an area of success in planning and execution. See fig. 7.

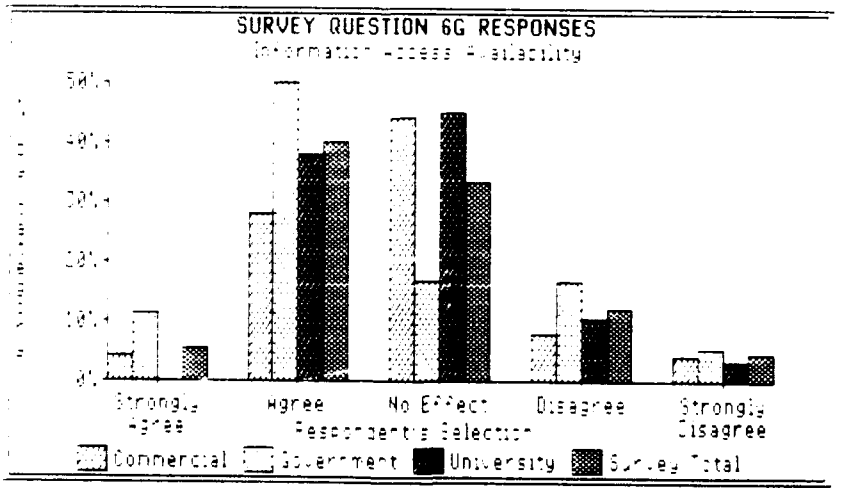

Figure 7. Survey Question 6G - Information Access/Availability.

h. Question 6H - Technical Guidance. An overwhelming majority of respondents felt this was not an area of great effect. This corresponds to the author's intent, since this parameter was added in an attempt to achieve a narrowly distributed normal curve. There is, to my knowledge, no literature or previous work which proves that researchers, or any managers, want more guidance, fig. 24, app. C.

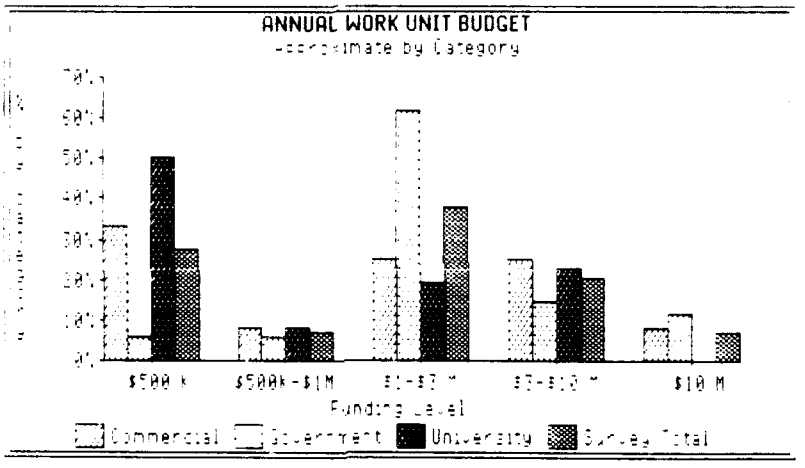

Figure 8. Annual Work Unit Budget by Category.

6. Question 7. The purpose of question 7 was to establish the correlation between budget level and span of control, and then budget level and long-range planning. The author sought to establish a difference between the three groups that would substantiate his theory. The significance of the relation between budget level and span of control was not pursued for the same

reasons stated in section III.B.3. The raw budget data for each category and the survey total is shown at figure 8.

The reader must keep in mind the reporting differences for each category. A university "budget" may be the amount of a grant for specific work and not include other costs. Commercial and government facility budgets routinely include all expenses, including fixed costs, labor costs and unique expenses.

7. Question 8. The purpose of question 8 was to investigate the relation between budgeting and planning within the 3 categories. The percent responding is shown in figure 9.

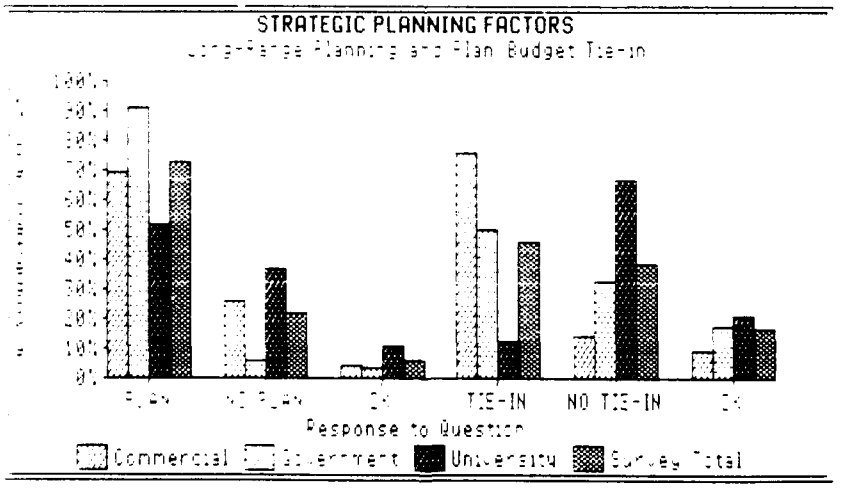

Figure 9. Strategic Planning Factors (No Response Recorded as DK for this Question).

The first set of values labeled "plan" indicate the percentage acknowledging a long-range plan. The second and third set correspond, respectively, to those without a plan and who do not know. The fourth, fifth and sixth set of values refer to question 8b,the budgeting and planning relation.

The ANOVA treatment of these variables was not conclusive below the 0.05 probability level but the treatment of questions 8 and 8b using the correlation procedure was significant. While all three categories registered positive values for the Pearson correlation coefficient, the level and significance values are worthy of note. The commercial category was 0.393 at $p < 0.05$, government: 0.526 at $p < 0.001$, and university: 0.451 at $p < 0.01$. This trend is not well depicted graphically because of the sample size differences and some confusion in clarity for question 8b.

The length of the long-range plan, Fig. 19, App. C, is representative of what one would expect from a group of middle-level managers. Normally, first-line supervisors and managers plan for one year or less, middle-level for 2 to 5 years and high-level for 5 or more. The figure indicates that the majority of respondents fall into the middle category.

8. Questions 9. This question was designed to pursue the same general topic as question 6, but with a slightly different focus. Respondents were asked to agree or disagree that there are sufficient levels of support for 9 system parameters. These parameters are believed, based on the literature review findings, to impact both defense and technical superiority.

a. Question 9a - Information Data Bases. The responses here further confirm the results of question 6g. There are no significant differences between the categories for this parameter and it received the lowest mean score for the total survey and for both the commercial and government categories, fig. 10.

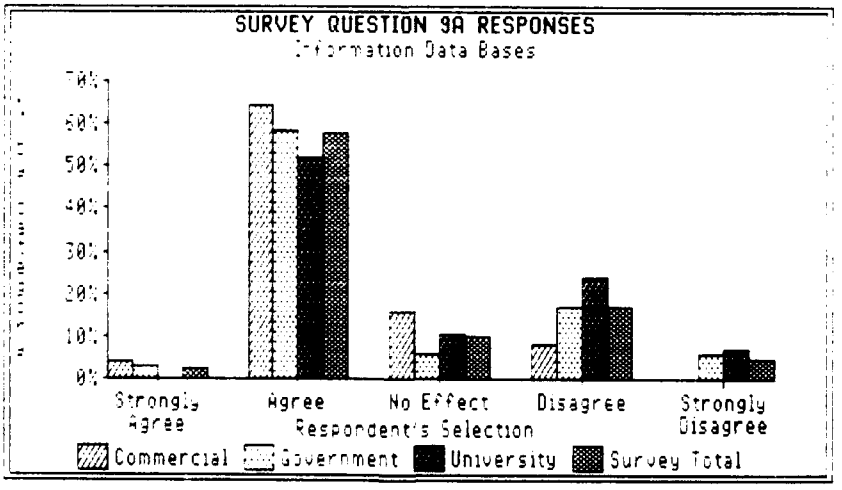

Figure 10. Information Data Bases by Category.

b. Question 9b - Research Facilities. The ANOVA procedure was again inconclusive for this response. The principal reason was that all three groups did not vary more than 0.5 of a point from the total mean. A general trend toward agreement exists as depicted by fig. 25, app. C.

c. Question 9c - Funding Support. As expected this parameter elicited strong responses, but the responses were not significantly different for each group. As shown in fig. 11, there are approximately 20% of the respondents that agree; another 44% that disagree; and 18%, the largest percentage of all 17 questions for that response, that disagree strongly. An unsuccessful attempt was made to find a correlation between funding support and any other parameter.

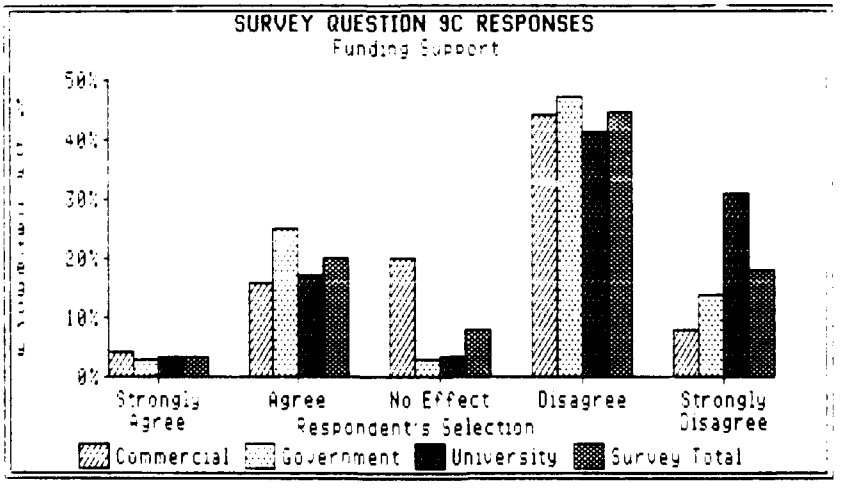

Figure 11. Survey Question 9C - Funding Support.

d. Question 9D - Entry-Level Education. Not surprisingly, the university group recorded the strongest attitudes to this question, fig. 26, app. C. There was no significant difference between groups, but the university group clearly felt that improvements could be made in this area by the U.S.

e. Question 9E - Raw Material Procurement. All three groups were again united in the opinion that ceramic raw materials were not a major concern for the U.S., fig. 27, app C. The means for the three groups only varied by 0.04 points total. No significant difference between groups.

f. Question 9F - Professional Development. Fig 28, app. C, shows an even distribution of responses. No significant variance between groups, but the university group produced the highest (disagreeable) mean. This may indicate a potential problem between university researchers and those in government, Table VI, app. D.

g. Question 9G - Research Equipment. The results of this question were significantly different at the $p < 0.05$ level with $F = 3.42$. The difference is attributable to the variance between the university and commercial groups. The two groups had a 0.85 point difference in means and varied 20% in 2 of 5 response levels, fig. 12.

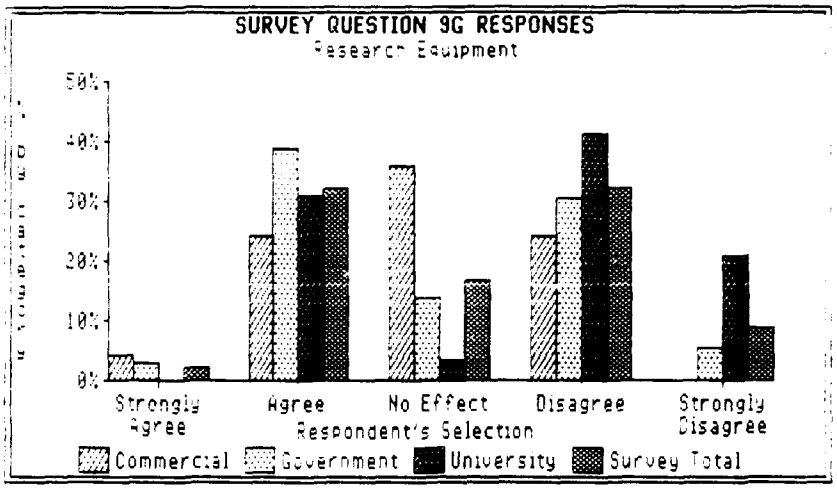

Figure 12. Survey Question 9G. Research Equipment.

h. Question 9H - Advancement Potential. The results of this parameter are normally distributed for the survey total and do not show any significant differences between categories. Analysis of the graph at fig. 29, app. C, along with several of the written comments at app B, indicates there is a genuine concern in the government sector about job security and advancement. Civil service has traditionally been one of the safer career choices to make, but the current budget crisis has brought great turmoil to this formerly stable environment.

i. Question 9I- Professional Standards. All three categories of respondents were again normally distributed as a group with no significant differences between the means or response levels, fig. 30, app. C.

10. Question 10. The purpose of this question was to provide the respondents a final opportunity to express their attitude in an open format. Table IV lists the frequency of responses in alphabetical order. Responses with less than two occurrences are omitted. Near duplicate responses have been summed when it did not alter the meaning of the response. The top 4 responses, based on summing 1st, 2nd and 3rd choices, were funding support (38), research facilities (21), research equipment (20) and quality of research (19).

Table IV. Responses to Question 10 - Research Issues. Frequency per Rank.

Research Issue	1st Rank	2nd Rank	3rd Rank
Employee Retention	1	2	2
Entry-level Education	3	5	2
Funding Support	23	10	5
Info Data Bases	4	1	2
Long-range Plans	3	1	1
Professional Development	2	1	5
Quality of Research	9	8	2
Research Efficiency	3	5	3
Research Equipment	7	7	6
Research Facilities	4	7	10
Researcher Productivity	3	4	6
Technical Support	1	1	4

The written comments made by respondents are compiled at app. B without analysis. Most of the remarks are self explanatory and verbatim.

From a management perspective, these results indicate the priority of effort should be placed on providing researchers with solid, consistent, multi-year funding support. This should include plans to improve or maintain research facilities and equipment resources. Communicate the plan to subordinates as soon as it is finalized. Second, emphasize the quality of research by eliminating administrative distractions and unnecessary reports; then concentrate on issues and technical solutions that support the organization's objectives. Finally, managers must instill in researchers, like all employees, the belief that they are important to the organization. Only then will they become productive, efficient contributors.

IV. CONCLUSIONS

The differences between the three categories of researchers are not significant for the majority of cases. While isolated dichotomies exist, the small size of this survey and the lack of strength of the relationships suggest the use of caution when applying these results to management applications.

The following conclusions are presented:

1. Funding support is the key issue within all three categories of researchers.

2. University researchers are extremely dependent on federally funded research programs for equipment procurement and general project funding.

3. The commercial researchers surveyed have yet to form a working relationship with government activities which would create a solid research triad.

4. The correlation between planning and budgeting indicates proportionately strong management procedures and policies in all three groups.

5. A majority of government researchers believe current federal policies adversely affect productivity and efficiency of research.

APPENDIX A

COVER LETTER AND QUESTIONNAIRE

APPENDIX A. COVER LETTER AND QUESTIONNAIRE

UNIVERSITY OF MISSOURI-ROLLA

September 3, 1990

[TITLE] [FIRST NAME, M.I.] [LAST NAME]
[INST]
[ATTN]
[ADDRESS]
[CITY], [STATE] [ZIP CODE]

Dear [TITLE] [LAST NAME],

I am a graduate student working on my Master's Degree in the Ceramic Engineering Department. My graduate degree studies are part of the United States Army Advanced Civil Schooling Program. I am presently an active duty Captain in the Corps of Engineers, tentatively scheduled to work as an R & D Coordinator for the Cold Regions Research & Engineering Laboratory in Hanover, New Hampshire.

The research I am conducting is an investigation of the strategies used by the Department of the Army (Defense) to facilitate it's Research and Development Program. I am focusing on the ceramic research field which, for the purpose of this survey, includes composites and the broader field of materials science.

I have designed a survey (questionnaire) directly related to this research. I hope you will be able to assist me by taking a few minutes to complete the survey and return it in the enclosed envelope. All responses are strictly confidential and your name will not appear with any specific response, nor will there be any direct connection between the survey responses and individual enterprises. My goal is to confirm or deny several hypotheses which I have developed during my literature search and field studies.

I hope to hear from you within the next several weeks.

Sincerely yours,

James R. Hann
Graduate Researcher

Enclosures: [#]

Figure 13. Cover Letter Used in Questionnaire Mailing.

Control Number _____

Ceramic Engineering Research & Development Survey

1. Which of the following major categories most accurately describes your present employment? (Circle appropriate response)

Government University Commercial/Industrial Other

a. Please specify your job title: _____

b. How long have you held this position: _____ years.

c. What is your age group?

< 25 yrs 26-35 yrs 36-45 yrs 46-55 yrs 56-65 yrs > 65 yrs

2. What percentage of your work unit's research is related to ceramics, ceramic composites, and/or ceramic related technologies and techniques? _____

3. How many professional/technical personnel are employed in your center, office, department, etc., (the work unit you supervise or are a member of)?

None 1-12 13-50 51-100 > 100

4. How many professionals, researchers and/or skilled technicians do you directly supervise?

None 1-5 6-12 13-25 > 25

5. Have you had any experience conducting research funded partially or fully by the Department of the Army (Defense)?

Yes No Don't Know

a. By some other government agency? Yes No Don't Know

b. Which agency(ies)? _____

c. What percentage is funded now by a government agency? _____

6. Would you agree or disagree that current federal strategies and policies, as you interpret them, have a **positive** effect on the following parameters of your research efforts?

	Strongly Agree		No Effect		Strongly Disagree
Quality of Research	___	___	___	___	___
Researcher Productivity	___	___	___	___	___
Research Efficiency	___	___	___	___	___
Employee Retention	___	___	___	___	___
Equipment Procurement	___	___	___	___	___
Raw Material Availability	___	___	___	___	___
Information Access/Avail.	___	___	___	___	___
Technical Guidance	___	___	___	___	___

Comments on additional areas of concern in your work unit?

Figure 14. Ceramic Engineering Research and Development Survey.

4. What is the approximate annual budget for your work unit?

$500,000 $500,000-$1 million $1-$3 million
$3-10 million $10 million

5. Does your work unit have a long-range plan for research and development activities?

Yes No Don't Know

a. If yes, what is the length of the plan ? _____

b. Is your annual budget tied to the long-range plan at the next higher budgeting level?

Yes No Don't Know

6. Do you agree or disagree that **there are sufficient levels** of the following systems to support our national defense and maintain the technical superiority/parity of the United States in this field?

	Strongly Agree	Agree	No Effect	Disagree	Strongly Disagree
Information Data Bases	___	___	___	___	___
Research Facilities	___	___	___	___	___
Funding Support	___	___	___	___	___
Entry-Level Education	___	___	___	___	___
Raw Material Procurement	___	___	___	___	___
Professional Development	___	___	___	___	___
Research Equipment	___	___	___	___	___
Advancement Potential	___	___	___	___	___
Professional Standards	___	___	___	___	___

7. Please rank order three of the research issues from questions 6 or 7 which you feel are critical to the success of your work unit's research. Rank 1 through 3 with number one being the most critical element. You may add elements of your own which you feel are more critical than those listed.

a. _____

b. _____

c. _____

Please feel free to comment on any areas of concern you have which you feel may enhance my understanding of your responses. If you would like an abbreviated copy of the results of this survey please make a note here. Thank you for your cooperation.

Figure 14. Ceramic Engineering Research and Development Survey (cont.).

APPENDIX B

UNCODED SURVEY RESPONSE DATA

APPENDIX B. JOB TITLE LISTING

Associate Professor	Ceramic Branch Chief
Ceramic Engineer	Ceramist
Chief, Bldg Matls Div	Chief, Ceramics Division
Chief, NIST	Chief-Ceramics Research Br
Computer Specialist	Department Head
Department Manager	Deputy for R & D
Development Staff Member	Director of Tech Svcs
Director, Ctr for Mat Sci	Director, High Temp Mat Lab
Director, Industrial Appl	Director, Tech Transfer Ctr
Division Director	Electronics Engineer
Executive V.P.	General Manager
Graduate student	IBM Fellow
Manager	Marketing Manager
Matls and Proc Engineer	Materials Engineer
Matls Research Engineer	Metallurgist
Physicist	President
President/CEO	Prin Mbr of Tech Staff
Process Engineer	Professor
Professor Emeritus	Program Manager
Project Chemist	Project Manager
Research Associate	Research Chemist
Research Engineer	Research Group Leader
Research Metalurgist	Research Physicist
Research Scientist	Research Specialist
Section Leader	Senior Research Engineer
Sr Chemical Engineer	Sr. Chemist

APPENDIX B. SURVEY COMMENTS

Too much "quick & dirty survey work - too little thinking and modeling of results.

If you are interested in working in ceramics R & D, I have enclosed my card.

Support(funding) from government agencies is usually annual or cannot be counted on if longer [than annually] due to annual budgets from Congress. Need long-range funding and cooperative planning of all facilities involved in research with government funds.

I regret that my information may be of minimal value - I have been retired for 3 years. I have, however, continued some research and am teaching at present, part-time, at the University of British Columbia.

NASA's primary mission in ceramics is civil aeronautics and space.

We are a small company with limited resources. Although we do supply material to government sub-contractors we are not directly involved in government research programs. Our experience with applying for government grants has been that it requires one full-time employee just to handle the

correspondences and paperwork required, We are not in a position to do that.

Because of the lack of U.S. government funding, I started research with funds from Japanese government agencies. At present from Ministry of Education and NEDO under MITI.

The key to national defense and technical superiority is good quality research which is geared to technical products that improve national defense and our technical superiority. Research for the sake of research won't help. We're already way ahead of everyone else in pure research.

My work related to ceramics and advanced materials has been associated with Dr. Blum's, who is a pioneer in preceramic polymer routes to ceramics. I believe that Dr. Blum's work is viewed as being too fundamental for U.S. government agencies and most of his support, $1M-$1.5M/year, comes from Japan.

Our independent R & D seems to be supported by short term funding , especially ceramics for the thermal protection system. We do get support from NASA.

This is too vague to answer accurately. [Question 6]

Generally we get the work done with federal support. However, requirements put on us lower the efficiency of our work.

I believe that too large a fraction of the U.S. R & D budget goes to defense related work and that fact lowers U.S. national security. [Question 9]

Note: This [survey responses] is biased by the fact that I am in a U.S. government laboratory which is scheduled to close in the next few years and is consequently suffering fiscal and problems.

We spend a lot of time on non-research related tasks (making vu-graphs, attending meetings, etc.). [Question 6]

So far, the work assignment has never lasted long enough to carry any long-term plan to completion. We spend a lot of time making up long-range plans. [Question 8]

Facilities, equipment, intelligence and raw materials are perhaps more critical than those listed, for without them we would be severely handicaped. The issues I listed above seem to be our biggest obstacles to job satisfaction.

The government, especially some of the labs tend to push for some technically unsound projects and tend to ignore some things that could be do-able. Also, the

agencies related tend to believe that "something better is always around the corner." Due to the build-up given, to attain research funding the using agencies don't buy developed new materials. You don't make money on research contracts - you lose! Eventually your company or your technology is bought by foreign owners.

Since there is only a limited chance for employment after graduation, there are limited reasons to pursue a science career.

My responses are somewhat naive as our company has not had any interactions with government agencies on research project funding. Overall, my concerns over the long-term competitiveness of the U.S. are: 1) Education - lack of talent entering technical fields, dwindling supply of college professors, and 2) Industry focus on short-term profits.

Having worked for military contractors, I feel the limitations are not funding, facilities,[or] tecnnically trained professsionals. Rather the limitations are technically incompetent management who are unable ot make sound technical decisions or provide long range strategies. Associated with thsi is the inability to wisely appropriate resources (people and facilities) to efficiently complete tasks.

Funding instabilities hurt morale and productivity. The organization's high standards are a source of pride. Good equipment aids productivity and is good for morale.

APPENDIX C

GRAPHICAL SURVEY DATA

APPENDIX B. GRAPHICAL SURVEY RESULTS

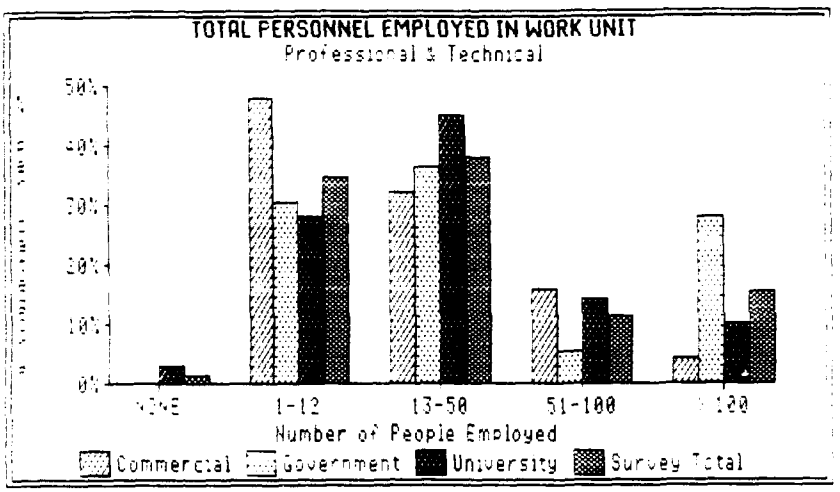

Figure 15. Question 3 Responses. Total Personnel Employed in Work Unit.

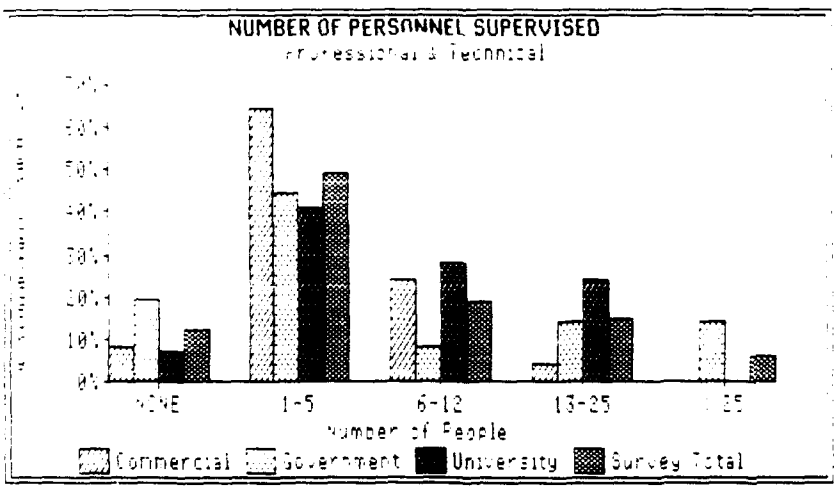

Figure 16. Question 4 Responses - Total Personnel Supervised.

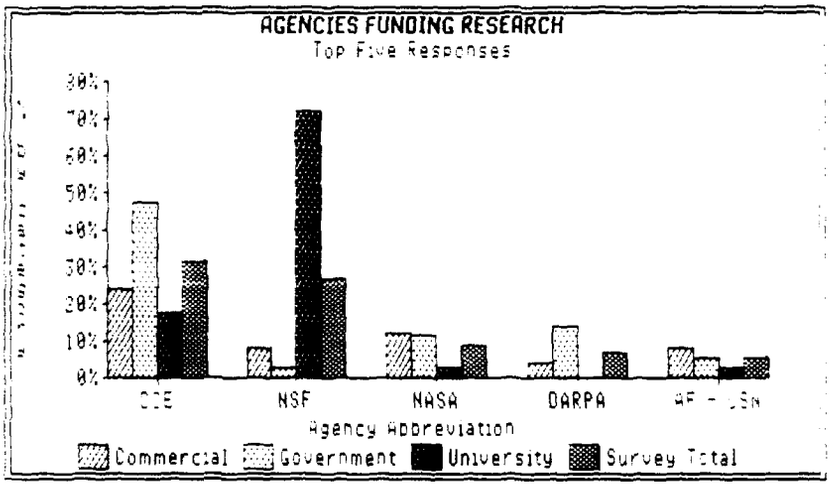

Figure 17. Question 5b Responses. Government Agencies Funding Research.

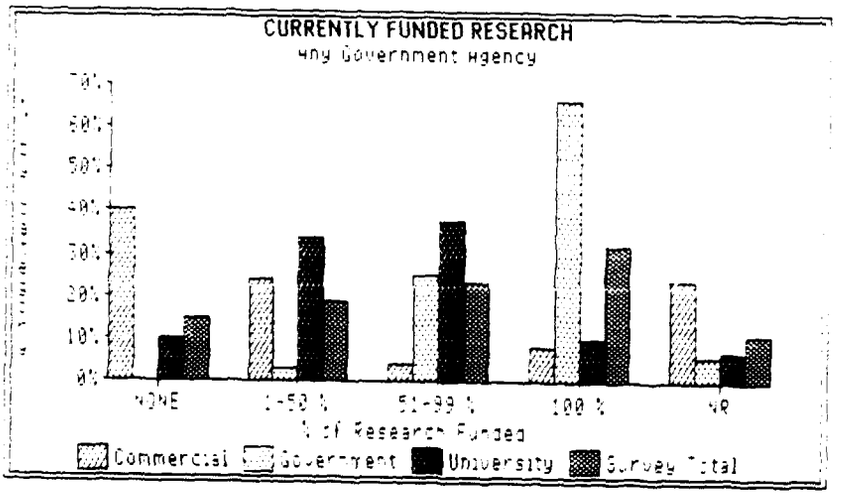

Figure 18. Question 5c Responses - Currently Funded Research.

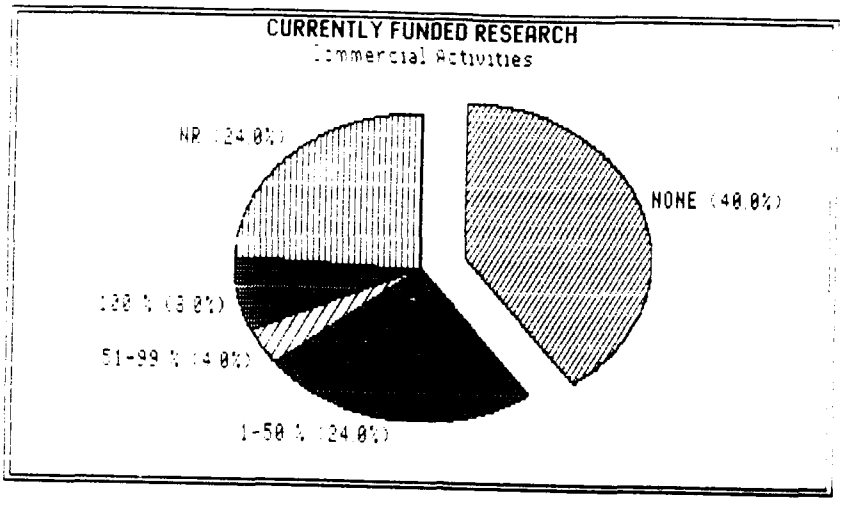

Figure 18a. Question 5c Responses. Current Research Funding - Commercial.

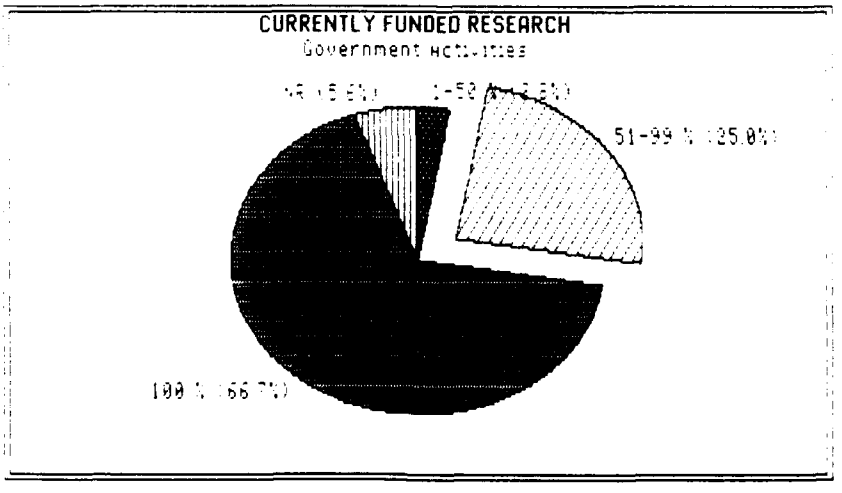

Figure 18b. Question 5c Responses. Current Research Funding - Government.

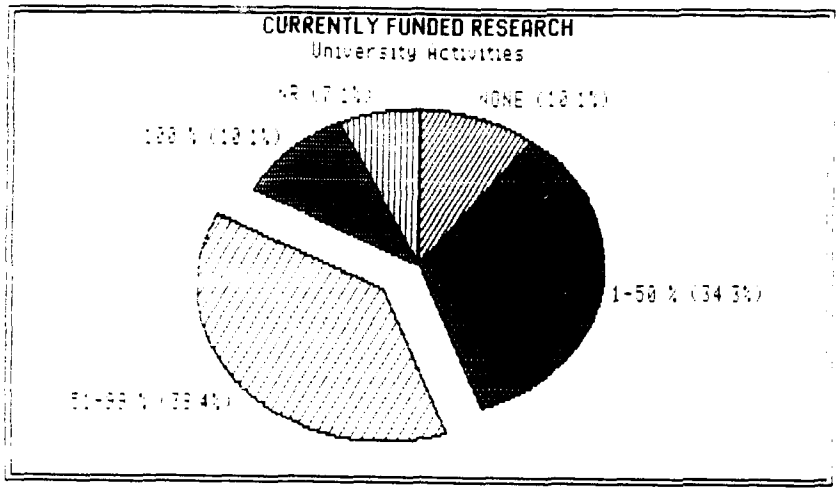

Figure 18c. Question 5c Responses. Current Research Funding - University.

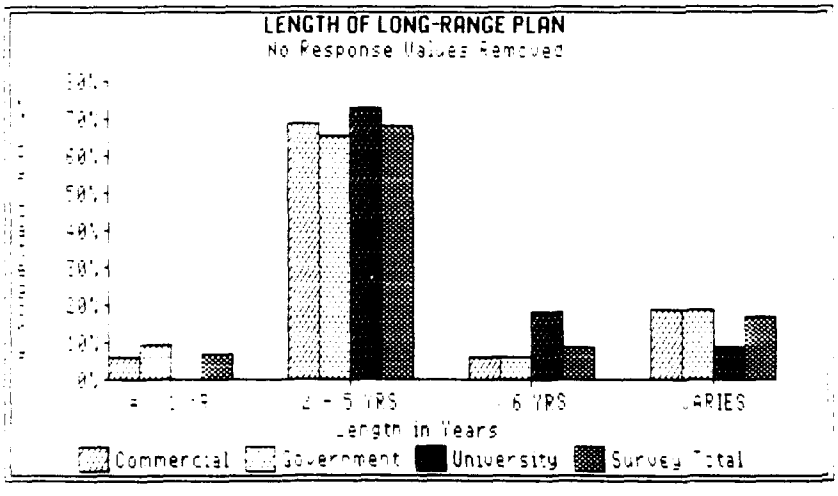

Figure 19. Question 8a Responses. Length of Long-Range Plan.

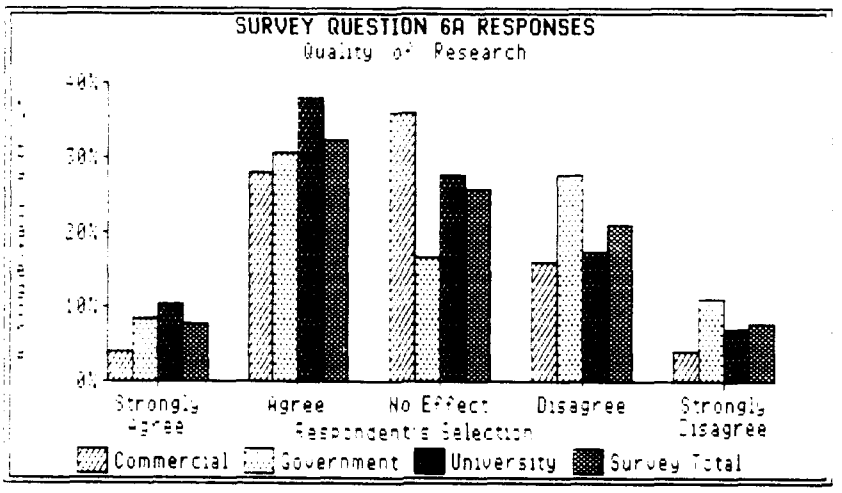

Figure 20. Question 6a Responses. Quality of Research.

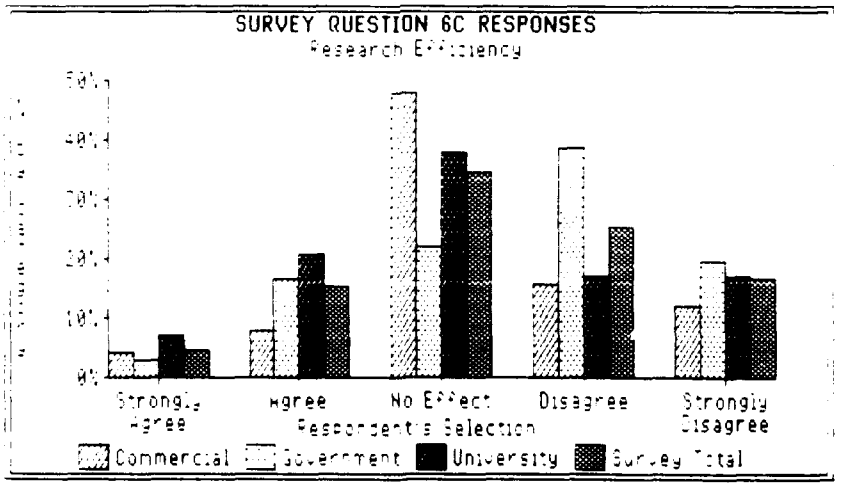

Figure 21. Question 6c Responses - Research Efficiency.

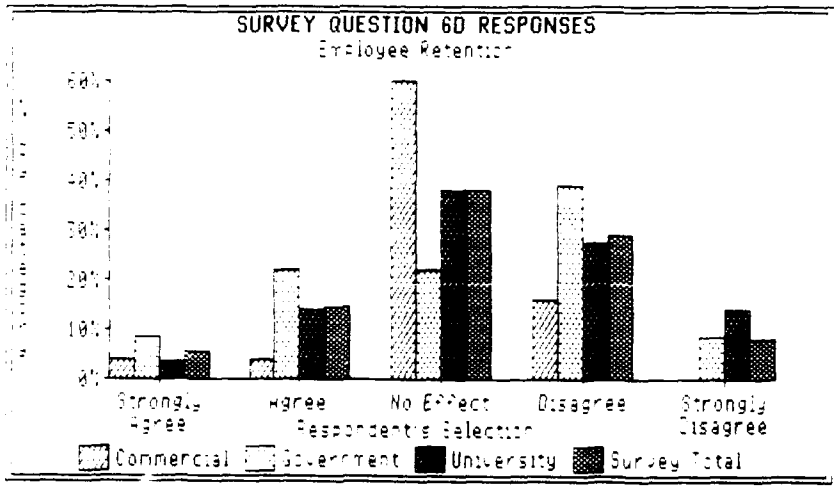

Figure 22. Question 6d Responses. Employee Retention.

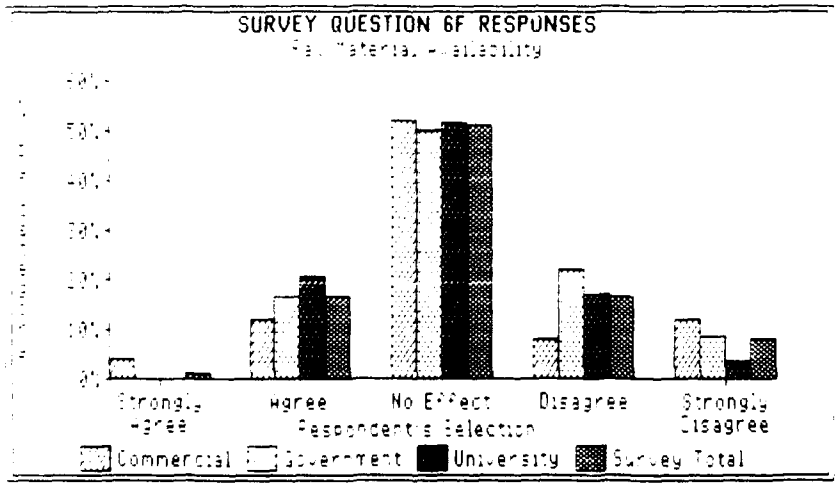

Figure 23. Question 6f Responses - Raw Material Availability.

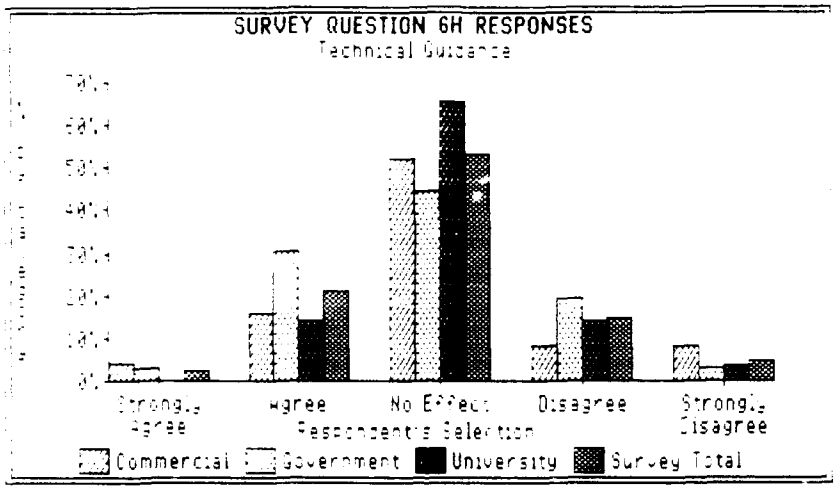

Figure 24. Question 6h Responses. Technical Guidance.

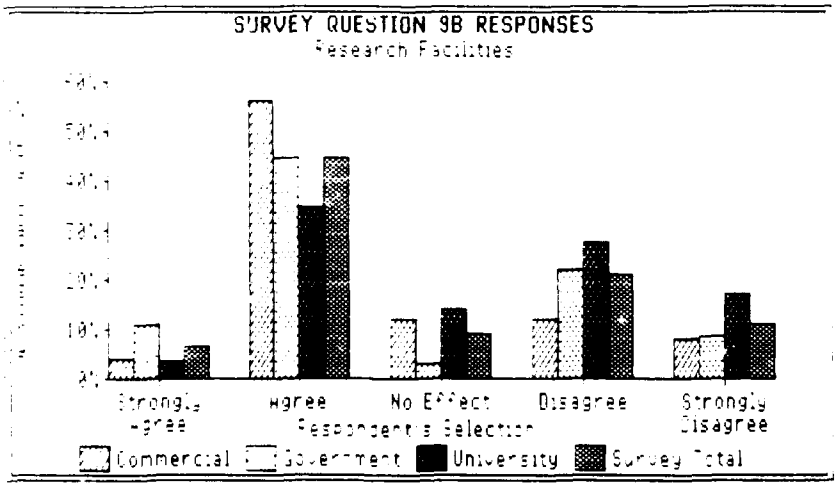

Figure 25. Question 9b Responses - Research Facilities.

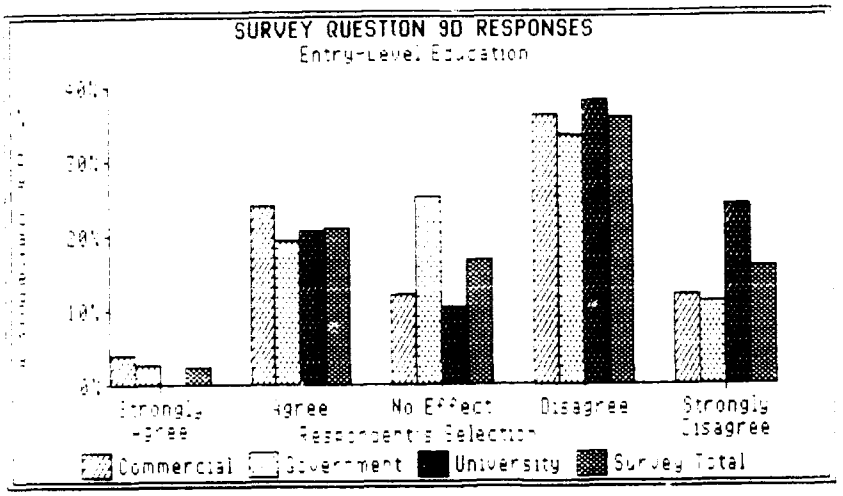

Figure 26. Question 9d Responses. Entry-Level Education.

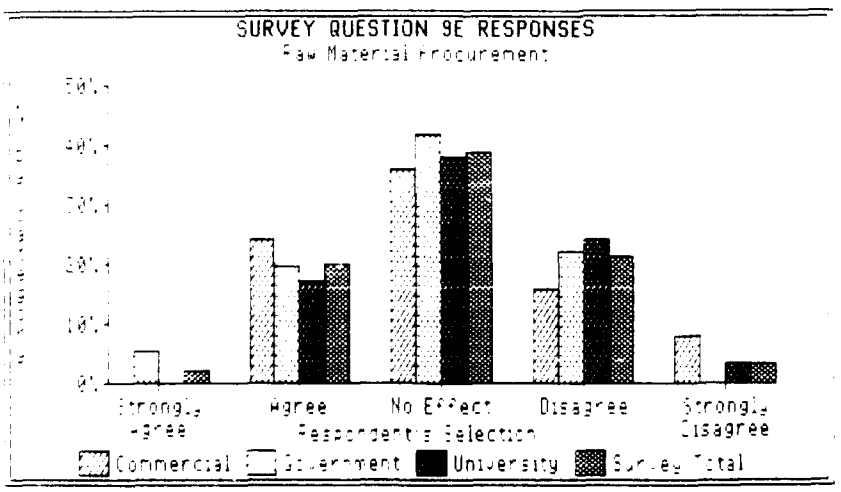

Figure 27. Question 9e Responses - Raw Material Procurement.

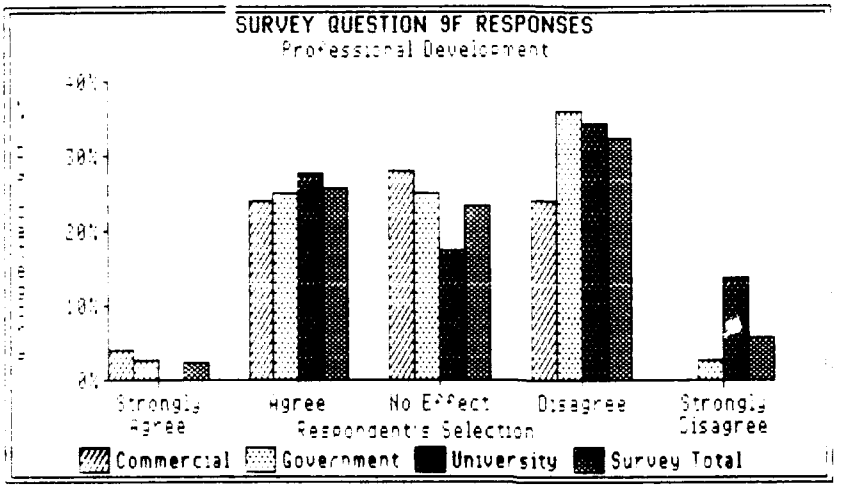

Figure 28. Question 9f Responses. Professional Development.

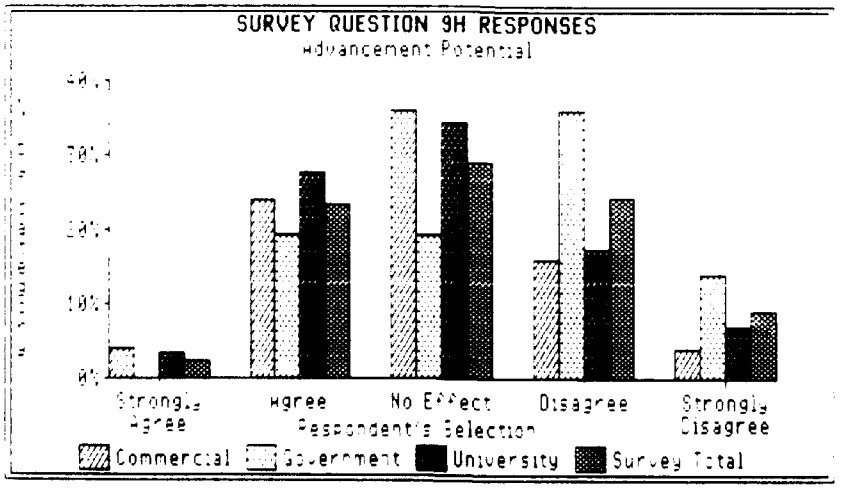

Figure 29. Question 9h Responses - Advancement Potential.

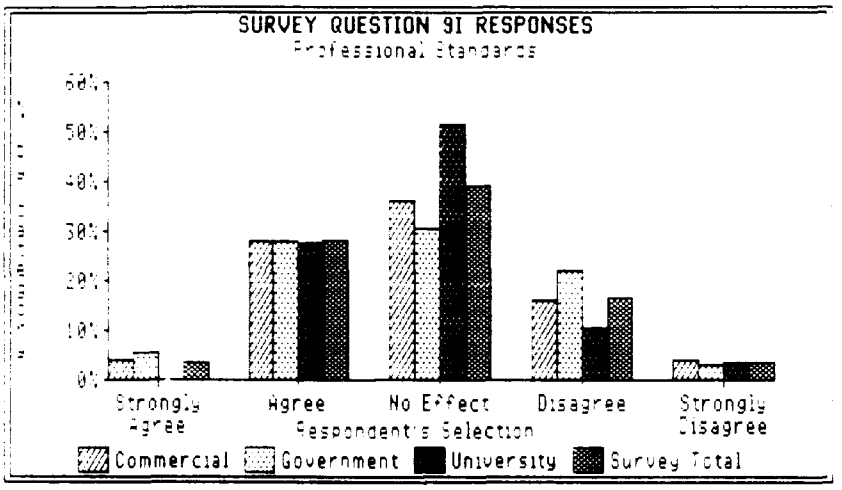

Figure 30. Question 9i Responses. Professional Standards.

APPENDIX D

TABULAR SURVEY DATA

APPENDIX D. TABULAR SURVEY DATA

Table V. Means and Standard Deviation Results (SAS Means Procedure).

DEP VAR	Sample Total N = 90 Mean--STD	Commercial N = 25 Mean--STD	Government N = 36 Mean--STD	University N = 29 Mean--STD
QUES 6A	2.72--1.26	2.52--1.29	2.86--1.37	2.72--1.10
QUES 6B	2.92--1.23	2.76--1.36	3.33--1.07	2.55--1.18
QUES 6C	3.24--1.23	2.88--1.42	3.55--1.08	3.17--1.18
QUES 6D	3.02--1.22	2.56--1.29	3.17--1.13	3.24--1.18
QUES 6E	2.95--1.30	2.84--1.34	3.36--1.13	2.55--1.35
QUES 6F	2.93--1.14	2.76--1.39	3.14--0.99	2.83--1.07
QUES 6G	2.57--1.07	2.44--1.23	2.56--1.08	2.68--0.93
QUES 6H	2.84--1.00	2.64--1.32	2.89--0.85	2.97--0.86
QUES 9A	2.37--1.19	2.12--0.93	2.31--1.28	2.66--1.26
QUES 9B	2.62--1.39	2.40--1.26	2.39--1.46	3.10--1.36
QUES 9C	3.33--1.41	3.12--1.36	3.19--1.47	3.69--1.37
QUES 9D	3.14--1.44	2.92--1.55	3.05--1.37	3.45--1.43
QUES 9E	2.60--1.34	2.60--1.44	2.58--1.23	2.62--1.42
QUES 9F	2.79--1.36	2.28--1.40	2.86--1.27	3.14--1.36
QUES 9G	2.90--1.34	2.56--1.26	2.72--1.32	3.41--1.32
QUES 9H	2.78--1.41	2.44--1.39	3.11--1.46	2.6[illegible]--1.32
QUES 9I	2.59--1.21	2.52--1.29	2.56--1.30	2.68--1.03

Author's note: No response value = 0, strongly agree = 1, agree = 2, no effect = 3, disagree = 4, and strongly disagree = 5.

Table VI. Selected Statistical Results (SAS ANOVA Procedure).

DEP VAR	Model F	Sig Prob	R-Square	C.V.
QUES 6A	0.53	0.589	0.012	46.66
QUES 6B	3.77	0.027	0.079	40.81
QUES 6C	2.37	0.099	0.051	37.34
QUES 6D	2.62	0.079	0.057	39.58
QUES 6E	3.44	0.036	0.073	42.74
QUES 6F	1.00	0.372	0.022	38.85
QUES 6G	0.36	0.697	0.008	42.03
QUES 6H	0.76	0.471	0.017	35.41
QUES 9A	1.44	0.242	0.032	50.20
QUES 9B	2.64	0.077	0.057	52.23
QUES 9C	1.39	0.254	0.031	42.24
QUES 9D	1.01	0.367	0.022	45.86
QUES 9E	0.01	0.994	0.000	52.09
QUES 9F	2.87	0.062	0.062	47.83
QUES 9G	3.42	0.037	0.073	45.04
QUES 9H	1.86	0.161	0.041	50.36
QUES 9I	0.15	0.859	0.003	47.09

Author's note: Model df = 2, Error df = 87, Sample N = 90, Value assignment as Table V, Sig Prob = significance probability associated with F value, C.V. = coefficient of variation.

BIBLIOGRAPHY

Acker, David D. 1990. Current Congressional Concerns and Actions. Program Manager, July-August, 4.

Adam,John A. 1990. Federal Laboratories Meet the Marketplace. IEEE Spectrum, October, 39-43.

Askeland, Donald R. 1989. The Science and Engineering of Materials. Boston, MA.:PWS-KENT Publishing.

Atwood, Donald J. 1990. Industrial Base: Vital to Defense. Defense, January/February, 16.

Devore, Jay L. 1987. Probability and Statistics for Engineering and Sciences. Monterey, CA: Brooks/Cole Publishing Company.

Fox, J. Ronald. 1988. The Defense Management Challenge - Weapons Acquisition. Boston: Harvard Business School Press.

Francis, Philip H. 1977. Principles of R & D Management. New York: American Management Association.

Hill, Christopher T. 1985. Impacts on the Government: II. In New Federal Policies For R & D: Proceedings of the twenty-eighth National Conference on the Advancement of Research held in Williamsburg 7-10 October 1984, edited by N.S. Levinson, 117-127. Lanham, MD.: University Press of America.

Hodgetts, Richard M. 1990. Modern Human Relations at Work. Orlando: The Dryden Press.

Institute for Defense Analyses. 1985. A Brief Assessment of the Structural Composite Materials Research in Universities in the United States. By R.L. Kerber. DTIC, AD-A166 665, December.

Kerlinger, Fred N. 1986. Foundations of Behavioral Research. Fort Worth: Holt, Rinehart and Winston, Inc.

Koontz, Harold, and Weihrich, Heinz. 1988. Management. New York, N.Y.: McGraw-Hill.

Lee, Jonathan A., and Donald L. Mykkanen. 1986. Advanced Materials Research Status and Requirements - Volume I - Technical Summary. NTIS, AD-A165 338.

Lee, Joseph W. 1990. The Improvement of Technology Transfer From Government Laboratories To Industry. Program Manager, September/October, 23.

National Research Council, Committee on Materials Science and Engineering. 1989. Materials Science and Engineering for the 1990s. Washington: National Academy Press.

National Science Foundation. 1990. Guide to Programs. Washington, D.C.: Government Printing Office.

Norman, Colin. 1990. Defense Research After the Cold War. Science, 19 January, 247.

O'Connell, Robert L. 1989. Of Men and Arms. New York: Oxford University Press.

The President's Blue Ribbon Commission on Defense Management. 1986. A Quest for Excellence - Final Report to the President. Washington, D.C.: GPO.

The President's Blue Ribbon Commission on Defense Management. 1986. A Formula for Action - A Report to the President on Defense Acquisition. Washington, D.C.: GPO.

The President's Blue Ribbon Commission on Defense Management. 1986. A Quest for Excellence - Appendix. Washington, D.C.: GPO.

Price, William J. 1967. Formulation of Research Policies in a Mission-Oriented Agency. In Formulation of Research Policies: Collected papers from the Gordon Research Conference on Formulation of Research Policies held in Santa Barbara January 30-February 4, 1966, edited by L.W. Bass and B.S. Old, 189-196. Washington: American Association for the Advancement of Science.

Rhea, John. 1990. Gulf Has Top Priority in Army Tech Initiatives. Army, November, 20.

SAS Institute Inc. 1985. SAS User's Guide: Basic, Version 5 Edition. Cary, NC: SAS Institute Inc.

SAS Institute Inc. 1985. SAS User's Guide: Statistics, Version 5 Edition. Cary, NC: SAS Institute Inc.

Schuman, Howard, and Stanley Presser. 1981. Questions and Answers in Attitude Surveys. New York: Academic Press.

Scott, William B. 1990. Defense Acquisition in the 1990s to Reflect New Military, Industry Strategies. Aviation Week and Space Technology, 19 March, 71.

Strickland, Jack C. 1989. Key Ingredients to Total Quality Management. Defense, March/April, 17-21.

Systems Planning Corporation. 1986. Advanced Materials Technology Project - Final Technical Report. By William L. Frankhouser. DTIC, AD-A169 767.

Teich, Albert H. 1985. Impacts on the Government. In New Federal Policies For R & D: Proceedings of the twenty-eighth National Conference on the Advancement of Research held in Williamsburg 7-10 October 1984, edited by N.S. Levinson, 105-116. Lanham, MD.: University Press of America.

U.S. Congress, Office of Technology Assessment. 1988. The Defense Technology Base: Introduction and Overview-A Special Report. Washington, D.C.: Government Printing Office.

U.S. Department of Defense. 1989. Critical Technologies Plan. Washington, D.C.: Government Printing Office.

U.S. Department of Defense. 1990. FY 1991 Small Business Innovation Research (SBIR) Program. Washington, D.C.: Government Printing Office.

U.S. Department of Interior, Bureau of Mines. 1990. The New Materials Society, Challenges and Opportunities, Volume 1, New Materials Markets and Issues. Washington, D.C.: Government Printing Office.

U.S. Department of Interior, Bureau of Mines. 1990. The New Materials Society, Challenges and Opportunities, Volume 2, New Materials Science and Technology. Washington, D.C.: Government Printing Office.

Van Creveld, Martin. 1989. Technology and War. New York: The Free Press.

VITA

James Russell Hann [redacted]. He received his primary and secondary education in the Warwick Valley School District. In 1972 he received an Associate in Applied Science degree in Mechanical Technology from Orange County Community College in Middletown, New York.

Following graduation, Mr. Hann operated his own business in lawn and garden maintenance and equipment. He successfully operated this business until 1979, when he enlisted in the U.S. Army.

Mr. Hann has attended numerous civilian and military schools since 1979 while serving in Virginia, Georgia, Missouri and the Federal Republic of Germany. He is a graduate of the Combined Arms and Services Staff School at Fort Leavenworth, Kansas, and received a Bachelor of Mechanical Technology degree from the University of Akron, Ohio in December 1985, graduating magna cum laude.

Mr. Hann is an active duty captain in the U.S. Army Corps of Engineers assigned to the University of Missouri-Rolla under the Army's Advanced Civil Schooling program. He is a member of the Society of American Military Engineers and the American Ceramic Society.